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**FACTORS DRIVING THE ADOPTION OF MOBILITY-MANAGEMENT TRAVEL APP: A
BAYESIAN STRUCTURAL EQUATION MODELLING ANALYSIS**

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ABSTRACT

The increasing complexity and mobility demand of transport services strains the transportation system especially in urban areas with limited possibilities to build new infrastructure. The solution to this challenge requires changes in travel behavior. One of the proposed means to induce such change is mobility-management travel apps. However, understanding the motivators underlying individuals' travel intentions is essential to design and evaluate their effectiveness. This paper aims to pinpoint and understand the drivers that influence individual travel decisions when using such apps. The analytical framework relies on goal frame theory in which individual's motives to use the app are grouped into three overarching goals namely, 1) gain, 2) hedonic and 3) normative goals. Furthermore, technophilia, social trust and place attachment are incorporated in the framework as to better explain user-sided heterogeneity. The case-study focuses on a hypothetical travel information system in Lisbon (Portugal) through a technology-use preference survey to 227 travelers. Bayesian Structural equation models revealed that the choice drivers are specific to individual users and depends on wide ranging factors that go above traditional economic and socio-demographic methods. The study revealed that firstly, trip efficiency improvement, enjoyment, social interaction and eco-friendly travel promotion are among those motives explaining the adoption intention. Secondly, there are different intentions among individuals depending on the users' motives. Third, technophilia exerts a positive influence on adoption intention. Fourth, the social dynamic behind the system, influence positively the use of the travel app.

Keywords: Travel app; Travel information; Behavior change; Mobility management; Technophilia

1 INTRODUCTION

2 The use of information-based mobility management strategies has been suggested already in the
3 beginning of the millennium but only gained momentum recently. A range of advanced traveler
4 information systems (ATIS) for mobility-management are presented by Gärling et al. (1). They
5 include navigation applications (apps) that notify the driver regarding route alternatives and
6 alerts, sharing information regarding joint trips, real-time information regarding public transport,
7 voluntary travel behavior change programs (VTBC) - also known as individualized marketing,
8 and travel role-modelling through social networks. These information-based strategies, besides
9 their low-cost to decision makers and wide availability to the general public, are potentially
10 powerful from the behavioral perspective. Problem awareness by giving information affects
11 perceived responsibility, behavioral control and social norms that in turn affect behavioral
12 intentions and actions (2, 3). They encourage informed decisions, thus encouraging people to
13 make a rational choice based on costs and benefits (4), and make "the right choice for the right
14 reasons" thus satisfying higher-order emotional needs of self-actualization, important for long-
15 term behavioral shifts (5).

16 Traditional VTBC solutions require person-based interaction, either by phone or home
17 interviews, which is inherently expensive and may induce biases stemming from social
18 interaction and communication. ATIS assisted VTBC offers opportunities to reduce the costs
19 associated with the need for human-based interaction. While most travel apps are still based on
20 the traditional view of digitized traffic information, the newest generation of ATIS include user-
21 based alerts, prescriptive advices (e.g., route alternatives and changes), reflective memory (e.g.,
22 the ability to save past and future trips and locations), and persuasive strategies (i.e., carbon
23 emission scores, interaction with social networks, and loyalty points and rewards) (6, 7). ATIS
24 replacing human interaction with digital schemes are currently under development offering,
25 among other possibilities, opportunities for communication and collaboration across users,
26 information sharing and social networking. Field experiments provide evidence that these new
27 features are important in influencing users to change their travel behavior (8–11).

28 The application of VTBC-based travel app is an active area of research. Ubigreen,
29 MatkaHupi, Peacox, SuperHub, Tripzoom and IPET are some examples of the mobile app which
30 are still under development (12). The underpinning concept is based on Fogg's framework (13)
31 in which system design is persuasive and explicitly attempts to change attitudes or behaviors or
32 both. This is achieved by raising awareness of individual choices, patterns, and the consequences
33 of activities. Persuasive technologies monitor human activities in relation to resource usage, and
34 provide information to the user for the purpose of motivating behavioral change (14).

35 Tailoring the travel solutions that support individual needs and expectations can possibly
36 lead to a powerful potential travel shift towards eco-friendly solutions. There is a wide
37 agreement that satisfying user needs are fundamental for the design, implementation and
38 dissemination of mobility-management travel apps aimed at encouraging VTBC (8, 12, 15, 16).
39 While the concept of needs is long-standing in empirical psychology for studying motivation,
40 with the shift toward cognitive theories this concept was largely replaced by goal-related efficacy
41 (17). This study contributes to the body-of-knowledge by offering to explore goal-framing theory
42 (18) a motivator for the intentions to use mobility-management travel app.

43 This study focuses on exploring the motivation to use the new real-time multi-modal
44 travel app for Lisbon, as ATIS for digital mobility-management assistance. The new multi-modal
45 travel app, a VTBC-based ATIS, is a multi-faceted mobile app including both travel information
46 and persuasive strategies such as health and environmental feedback, tailoring travel options,

self-monitoring, tunneling users towards green behavior, social networking, nudging and gamification elements. Due to the collaborative feature of this new generation of travel apps, a critical mass is essential for market penetration and use (16). There are three behavioral change elements that may induce target behavior through using ATIS: motivation, ability and triggers for behavioral change (12). Our study aims to explore these aspects through the lens of social psychology and social science. In that, a better grasp of the motivators and barriers for ATIS market penetration will aid authorities and private entrepreneurs to design effective and appealing ATIS, eventually translating into wider potential of VTBC. How ATIS have an influence is highly dependent on how users interface with the system. Noticeably, this process is not distinctly technological, but has a social dimension, which forces a socio-technical evaluation (16).

BEHAVIOURAL FRAMEWORK

Goal-framing theory

In an environmental context, goal-framing theory argues that, in every situation individuals want to achieve a goal which incorporates certain kinds of motives. Motives are separated into three overarching categories of goals according to core desires and needs they satisfy. The goals, which are likely to be situation dependent instead of stable across situations, govern or frame individuals information processing and their action. Thus, they influence individuals' attitude, feelings and actions. The three categories of goals are hedonic goal-frame "to feel better right now", gain goal-frame "to guard and improve one's resources", and normative goal-frame "to act appropriately" (18).

While simple navigation apps are mostly driven by their functional value, the use of a VTBC-based travel app is likely to embrace hedonic motives as well as the aspects of social responsibility and personal morality. Hence, as recommended by Dickinson et al. (16), this study investigates different motives in the framework of goal-framing theory as backbone for user attraction and engagement. We hypothesized that there are three different goal frames which explain the use of VTBC-based travel app.

Technophilia

Consumer attitudes and psychological factors can be critical for the marketing of innovative technologies which affect their success. With the purpose of analyzing these factors, we investigated the role of technophilia which refers to "a person's openness, interest in and competence with (innovative) technologies". Technophile attitude comprises three components namely, affective (e.g. satisfaction, anxiety or enjoyment), behavioral (e.g., experience or frequency of use), and cognitive (e.g., technology self-efficacy) (19). Prior literature supports the direct effect of technophile attitudes on innovation adoption behavior. For example, the potential target groups for electric bike (20), electric vehicles (21) and advanced travel information systems (19) are among people who are technophiles with an affinity to innovation and technology. Therefore, we hypothesized that technophilia has a positive relation with the use of VTBC-based travel app.

Social trust and place attachment

One of the main limitations of persuasive technologies is to focus on targeting specific behaviors and choices of individuals instead of proposing more collective approaches, which address the relevant communities that could have a higher impact on adoption (14, 22). With exclusive focus on individuals and their responsibility to use the system, the promotion of sustainable travel

behavior might not be achieved due to disregarding the social dynamics and the need for change at other scales beyond the individuals (23, 24).

To enrich the behavioral framework as well as address the limitation, we incorporated the notion of 'social trust' in to the model which is the kind of trust that individuals place on each other. Beside values, the importance of trust and its role as motivator for goal-directed behavior were highlighted by prior studies since trust reinforces peoples' engaging behavior i.e. acceptability and public involvement (25, 26). Individuals with more social trust may have more of a tendency to pursue the common good of society, promoting participation in collective action. It is mainly due to the fact that they tend to believe other members will also be concerned with and collaborate to protect the common good (27).

Place attachment is another factor often assumed to affect residents' attitude and behavior in relation to local issues and collaborative actions. Place attachment refers to an affective bond that people establish with specific place and it is widely viewed as an important part of human identity. Considering people's emotional connections with the city may provide a better understanding of their motivations, reactions to, and participation in local community-based action (28, 29).

As suggested by Ajzen and Fishbein (30), general attitudes do not have a direct effect on specific behaviors but they are indirect determinants through situation-specific beliefs, operating via their impact on generating situation-specific cognition. In this paper, social trust and place attachment are general attitudes, thus we investigate their effects on intention to use VTBC-based travel app mediated by the goal-frames.

The Conceptual Framework

Figure 1 describes the conceptual behavioral framework. Based on the above literature review, the proposed framework led to the following research hypotheses;

H1: There are three different groups of motives regarding the use of VTBC-based travel app which explain its adoption.

H2: Technophilia relates positively to adoption intention.

H3: Social trust and place attachment have a positive effect on use intention, mediated by goal-frames.

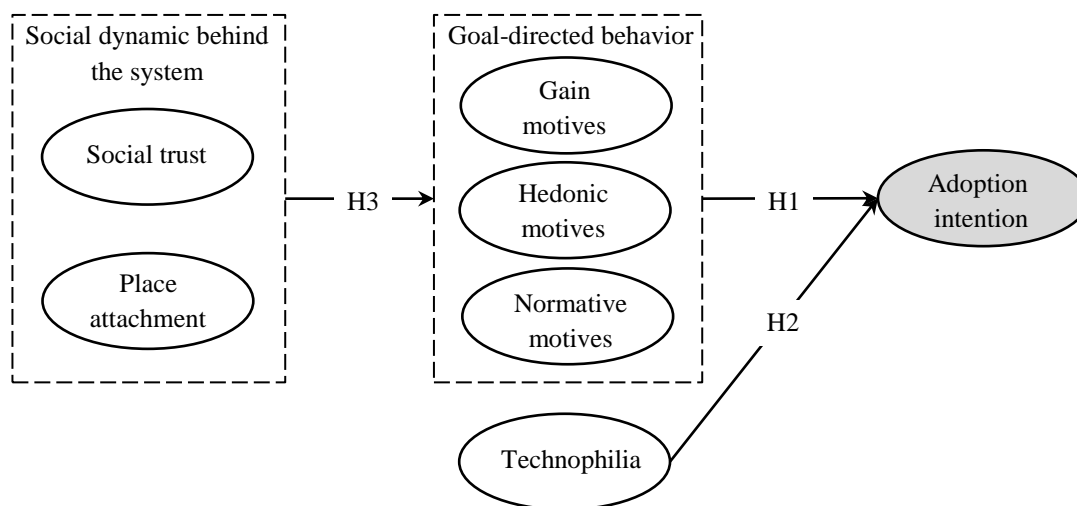


FIGURE 1 Behavioral framework

MODELING APPROACH

The behavioral model structure representing the research hypotheses was investigated by applying Bayesian structural equation model (BSEM). Bayesian methods are better equipped to model data with small sample sizes (31).

Bayesian structural equation model

The model contained three sets of equations presented below;

$$x = \Lambda\xi + \varepsilon \quad \text{and} \quad \varepsilon \sim N(0, \Psi_\varepsilon) \quad (1)$$

$$\xi = BS + \omega \quad \text{and} \quad \omega \sim N(0, \Psi_\omega) \quad (2)$$

$$y = \Gamma\xi + \delta \quad \text{and} \quad \delta \sim N(0, \sigma^2) \quad (3)$$

Eq. (1) links the measurement indicators to the latent variables. x is a vector of indicators describing a random vector of latent variable ξ ; Λ is a matrix of the loading coefficients obtained from the regressions of x on ξ ; and ε represents random vectors of the measurement errors which is distributed as $N(0, \Psi_\varepsilon)$. If ξ is exogenous (hereafter presented by ξ^*), then the latent construct is assumed to be distributed as $N(0, \Phi)$ which Φ is factor covariance matrix.

Eq. (2) links the (endogenous) latent constructs ξ to individual characteristics. S is a vector of the respondents' individual characteristics (e.g. socio-economic, travel habit etc.) and B are the parameters representing the regression relations. The error term is ω which is a vector following a normal distribution with covariance matrix Ψ_ω .

Eq. (3) represents regression relations between the latent variables and the dependent variable y . In this equation, y is the likelihood level of using the new information system in accordance with the behavioral framework. Γ is a matrix of the coefficients obtained from the regressions of y on ξ .

In Bayesian analysis, it is needed to specify a full likelihood and prior distributions for the parameters. In this study, the full likelihood function, including the latent variables, has the following form:

$$\mathcal{L}(y, x, \xi, S|\Theta) = \prod_{i=1}^n \{N(x_i|\Lambda\xi_i, \Psi_\varepsilon) \times N(y_i|\Gamma\xi_i, \sigma^2) \times N(\xi_i|BS_i, \Psi_\omega) \times N(\xi_i^*|0, \Phi)\} \quad (4)$$

Where n is the number of observations and $\Theta = (\lambda, \gamma, \beta, \psi_\varepsilon, \psi_\omega, \phi, \sigma^2)$ is the vector of the model parameters. To complete the model specification, it is needed to choose priors for each of the parameters. There are three main types of prior probability distributions namely, informative, uninformative, and weakly informative that vary in their degree of (un)certainty about the model parameters. In order to avoid the influence of priors on the estimations, uninformative priors are specified.

The joint posterior distribution for the parameters and latent variables is computed, following Bayes' rule, as

$$P(\Theta, \xi|y, x, S) = \frac{\mathcal{L}(y, x, \xi, S|\Theta)P(\Theta)}{\int \mathcal{L}(y, x, \xi, S|\Theta)P(\Theta)d\xi d\Theta} \quad (5)$$

Eq. (5) is the complete data likelihood multiplied by the prior and divided by the marginal likelihood. Calculating the marginal likelihood is a difficult computational problem, since it requires computing very high-dimensional integrals. To address this issue, Markov chain

Monte Carlo (MCMC) methods can be used to sample from the joint posterior distribution. “Due to the conditionally normal linear structure of the SEM and to the choice of conditionally priors for the parameters, MCMC computation can proceed through a straightforward Gibbs sampling algorithm” (32).

BSEM with cross-loadings and residual correlations

Consider Eq. (1) which is the measurement part of the model. The corresponding covariance structure is presented as

$$\text{Cov}(x) = \Lambda\Phi\Lambda^T + \Psi_{\epsilon} \quad (6)$$

The residual covariance matrix in Eq. (6) is usually assumed to be diagonal; however, some residuals might be correlated because of the omission of some minor factors. In BSEM without cross-loadings, zeros are specified in Λ for the factor indicators that are hypothesized to not be influenced by certain factors. Having a zero loading can be considered as a prior distribution with both mean and variance equal to zero. Whereas, in BSEM with correlated residuals, the assumption of diagonal residual covariance matrix does not hold. In this study, we consider a prior with mean zero and a normal distribution with small variance for cross-loadings (not main loadings). The choice of informative prior $\lambda \sim N(0,0.005)$ generate a prior where 95% lies between -0.14 and +0.14. A loading of ± 0.14 is regarded a minor loading, suggesting that this prior basically provides the cross loading near to zero, but not precisely zero (33).

Model fit and model comparison in Bayesian context

Model fit in the Bayesian context relates to assessing the predictive accuracy of a model, and is referred to as posterior predictive checking (33, 34). Posterior predictive checks are, “simulating replicated data under the fitted model and then comparing these to the observed data” (34). Therefore, posterior predictive is used to “look for systematic discrepancies between real and simulated data”(34). Any discrepancy between the generated data and the real data suggests possible model misfit. In this context, posterior predictive p-value (ppp) is an indicator for the model fit which is computed by chi-square discrepancy function. The ppp value around 0.50 is the indicator of a well-fitting model.

Deviance Information Criterion (DIC) is a Bayesian generalization of the Maximum Likelihood AIC and BIC. The DIC compares candidate models with respect to their ability to predict new data of the same kind. The DIC protects against overfitting by penalizing models with larger numbers of effective parameters. When comparing different candidate models for the same data, smaller values of DIC suggest better predictive ability similar to BIC (34).

CASE STUDY

This study is a part of PhD project aiming at exploring to what extent a new advanced real-time multimodal travel app could promote eco-friendly travel behavior in the City of Copenhagen. The case study is also extended to Lisbon Metropolitan Area (LMA), which is the focus of this paper. The new travel app, which is still under investigation, is expected to include features such as multi-modal real-time information, multi-criteria route planning on the basis of time and cost, multi-modal choice combinations, ridesharing opportunities and easy payment. In order to induce behavioral change, persuasive strategies are also considered by the system.

The new travel app is supposed to provide the users with information about CO₂ emissions produced/saved by taking different travel options and the amount of calories burnt by

1 taking active modes. It is also possible to monitor CO2 savings and calories consumption over
 2 time. Moreover, the app enables its users for registration to an environmental-friendly loyalty
 3 program: the more environmental-friendly itinerary they take, the more bonus points they earn.
 4 The bonus points can be used to get some free services (through vouchers) or public transport
 5 tickets. The collected bonus points and travel information i.e. CO2 emissions saved and calories
 6 burnt could be shared on social media.

8 **SURVEY DESIGN AND PARTICIPANTS**

9 A tailor-made web-based questionnaire was designed according to the developed behavioral
 10 framework. At the beginning of the questionnaire, participants were supported with information
 11 related to the functionalities and features of the new travel app such as multimodal travel
 12 information, incorporated persuasive strategies, bonus points, the policy of monitoring their
 13 travel behavior etc.

14 The survey elicited the following information; 1) the likelihood of using the app
 15 measured on a 5-point Likert scale ranging from highly unlikely to highly likely 2) a set of user
 16 motives to use the app to estimate the constructs in relation to goal-framing theory 3) technophile
 17 attitudes captured by individual attribute of openness and interest towards smartphone
 18 application 4) individuals' attitudes of social trust and place attachment and 5) a set of
 19 background variables such as socio-economic information, travel habits, travel information use
 20 habits etc. The statements of all attitudinal variables (i.e. the three goal frames, technophilia,
 21 place attachment and social trust) were measured using the 5-point Likert scale ranging from
 22 strongly disagree to strongly agree.

23 With respect to goal-framing theory, respondents were asked the question how using the
 24 new travel app can help/enable them to achieve different travel-related goals. Gain goal-frame
 25 incorporated items related to functional value of the system to increase trip efficiency such as
 26 time savings for travelling and information searching as well as effort savings for searching
 27 information. Trip efficiency was found as the most desired for the users of travel information
 28 (35, 36).

29 The second goal-frame explored motives regarding the game elements of app including
 30 self-monitoring, information sharing and eco-point collection. As suggested by Muntean (37),
 31 the application of game elements in non-gaming systems combines two type of motives; "on one
 32 hand using extrinsic rewards such as levels, points, badges to improve engagement while striving
 33 to raise feelings of achieving mastery, autonomy and sense of belonging". By extension,
 34 Vassileva (38) suggested that social motivation also plays a role, such that the social aspect of
 35 such systems might influence user behavior. In our case study, social motivations could be
 36 related to the possibility of competition and social comparison provided by sharing information
 37 on social media.

38 Normative goal-frame investigated items related to acting appropriately in line with
 39 sustainable travel behavior such as adopting environmentally-friendly travel alternatives and
 40 making contribution to the city CO2 emission reduction.

41 Technophilia was measured with statements reflecting emotional and cognitive attitudes
 42 towards using smartphone applications. The statements were inspired from the work of Seebauer
 43 et al. (19) who investigated the attribute of technophilia in the context of online travel information
 44 systems.

The statements related to social trust and place attachment were borrowed from the concept of community resilience, originally developed by Leykin et al. (39) for community disaster management. The statements were shortened and adapted to the context of transport.

Individual characteristic comprised socio-economic variables, travel habits, past travel experiences and information use habits. The travel habits were asked as the frequency of traveling by car, public transport and active modes. The frequency was measured on a 5 Likert scale including never/rarely, less than 3 days a month, once a week, 2-3 days a week and daily. The respondents were also asked to give information about the perceived time with the modal choice and situational attributes, namely the home-work distance and home/work locations. The travel information use habits were asked as the frequency of consulting with travel information systems separately for car, public transport and active modes. The frequency of information use was measured on a 5 Likert scale including never, rarely, sometimes, often and always.

The survey was administered from 1st May to 1st June 2017 to a sample of commuters who are older than 18 and reside or work in the LMA. The survey yielded 227 complete responses. Table 1 describes the sample socio-economic characteristics.

TABLE 1 Sample Characteristics, Total Sample Size = 227

Variable	Categories				
Gender	Male 55%	Female 45%			
Age	Age 18-29 25%	Age 30-39 20%	Age 40-49 25%	Age 50-59 15%	Age>60 15%
Education	High school 1%	Tertiary 13%	Bachelor 44%	Graduate 42%	
Employment	Student 22%	Part time 2%	Full time 64%	Other 12%	
Family status	Single no children 23%	Couple no children 45%	Single with children 5%	Couple with children 27%	
Commute origin	Center 52%	Suburbs 31%	Rural/Outer suburbs 17%		
Commute destination	Center 80%	Suburbs 8%	Rural/Outer suburbs 12%		
Commute distance	0-5 km 25%	5-10 km 21%	11-20 km 27%	21-30 km 16%	> 30 km 11%
Income group	Low 19%	Medium 34%	High 32%	No-answer 15%	

The sample characteristics are in line with the survey aim and scope to target commuters in the LMA. The sample is gender balanced and includes adults either full time employees or university students.

RESULT

Factor analysis

All the constructs of the behavioral framework including the goal-frames, technophile, social trust and place attachment were first revealed by exploratory factor analysis. The survey data showed good internal consistency with Cronbach's alpha 0.88 and good sampling adequacy with Kaiser-Meyer-Olkin (KMO) = 0.83. The determinant of the Spearman correlations matrix equal

to 1.58E-05 established the absence of multi-collinearity, and the Bartlett's test for sphericity rejected the null hypothesis of an identity correlations matrix. Principal axis factoring with oblique "promax" rotation generated the six factors of the behavioral framework. Tables 2 show the generated factors, the factor loadings of the dominant items and their descriptions. The cut off of 0.4 were set to retain a set of items representing the factors. The Cronbach's alpha of each factor is also presented in brackets. All the Cronbach's alphas are above 0.7 reflecting good internal consistency.

As shown in Table 2, factor F1 "Gain motives" incorporates all statements related to the gain motive of increasing trip efficiency by using the travel app. Factor F2 "Hedonic motives" includes statements related to receiving a feedback and reward as well as gaining social approval (i.e. sharing information) which reflects users' perceptions of the value of the game elements. Factor F3 "Normative motives" is associated with the value of using the travel app to travel more environmental friendly. Factor F4 "Technophilia" includes four items related to technology-related self-concept. F6 includes three items reflecting "Social trust" i.e. the shared belief that the members of the community will effectively cooperate and work towards making the city more sustainable. F7 "Place attachment" is associated with the individual's willingness to be updated about transport related projects and engage in the related voluntary activities in order to contribute to sustainable development of the city.

TABLE 2 Rotated Factor Matrix For Attitudinal Variables

Factor name (Cronbach α)	Item	Factor loadings
F1 (0.91) Gain motives	GM1	reduce my travel time
	GM2	be on time
	GM3	be faster and more efficient trip
	GM4	get pop-ups with alternative travel modes/ routes, when there is disruption
	GM5	reduce time spend and difficulty for travel information search
	GM6	arrive on-time
F2 (0.76) Hedonic motives	HM1	be rewarded with bonus points for eco-friendly behavior
	HM2	monitor amount of calories burnt while travelling
	HM3	share information with other users
	HM4	share my saved CO2 due to my eco-friendly behavior on social media
F3 (0.79) Normative motives	NM1	cycle more
	NM2	make healthier choices
	NM3	reduce the CO2 level and air pollution in Copenhagen area
F4 (0.80) Technophilia	TPH1	I usually like to install interesting new apps
	TPH2	I regularly use apps for payments, reservations, errands etc.
	TPH3	I am enthusiastic about GPS and travel apps
	TPH4	I think it is exciting to try new apps
F5 (0.74) Social trust	ST1	I can count on people in city to travel in an environmentally sustainable manner
	ST2	I trust that Lisboners are willing to contribute to assure a sustainable future
	ST3	I believe that environmental concerns are shared among all the residents in city
F6 (0.84) Place attachment	PA1	Participating in transport-related test projects in my city is important to me
	PA2	Knowing more about new travel apps in my city is important to me
	PA3	Knowing more about how to make my city sustainable is important to me

Model estimation results

The model was estimated using the BAYES estimator in MPlus due to the relatively small sample size (40). To evaluate model quality, ppp for model assessment, and DIC for model choice were used. We implemented two BSEMs in Mplus i.e. with and without cross-loadings. The BSEM with zero cross loadings (Model 1) had the PPP value of zero and DIC equals to 13305. The BSEM with cross loadings and residual covariance (Model 2) had the PPP of 0.262 and the DIC value of 13092.

Model 2 is preferred since it provides an acceptable PPP and a lower DIC. As suggested by Muthén and Asparouhov (33), a ppp value greater than 0.05 is a reasonable indicator of acceptable fit. The remaining tables are based on the estimate of Model 2.

Table 3 displays the estimates of the measurement equations of the latent variables from Model 2.

TABLE 3 Estimates of the Measurement Equations

	Indicator	Gain motives	Hedonic motives	Normative motives	Technophilia	Social trust	Place attachment
Gain motives	GM1	1.000	-0.009	0.063	0.071	-0.004	0.002
	GM 2	1.154*	-0.016	0.048	0.013	-0.042	-0.047
	GM 3	1.073*	0.001	0.063	-0.022	0.017	-0.024
	GM 4	0.789*	0.067	0.024	0.090	0.010	0.068
	GM 5	0.939*	0.102	0.015	-0.042	0.012	0.011
	GM 6	1.076*	0.053	-0.028	-0.048	0.003	-0.016
Hedonic motives	HM1	0.047	1.000	0.008	0.028	-0.058	0.060
	HM 2	0.082	1.027*	0.070	0.091	0.000	-0.060
	HM 3	0.207*	0.659*	-0.011	0.013	0.049	0.019
	HM 4	-0.032	0.819*	0.095	0.006	0.020	0.010
Normative motives	NM1	0.004	0.024	1.000	0.024	-0.006	-0.032
	NM2	0.018	-0.026	0.862*	0.048	-0.021	0.023
	NM3	0.235*	0.118*	0.528*	-0.023	0.051	0.020
Technophilia	TPH1	-0.023	0.018	0.015	1.000	-0.012	0.021
	TPH2	-0.015	0.038	-0.006	0.931*	0.030	0.015
	TPH3	0.067	-0.001	0.054	1.005*	0.007	0.051
	TPH4	0.068	0.065	0.063	0.925*	0.042	0.022
Social trust	ST1	0.005	0.032	0.019	0.025	1.000	-0.003
	ST2	-0.039	-0.067	-0.007	0.010	2.100*	0.008
	ST3	-0.057	-0.019	-0.060	-0.005	2.057*	-0.009
Place attachment	PA1	-0.068	-0.045	0.020	0.001	-0.023	1.000
	PA2	0.053	-0.062	-0.055	0.134*	0.000	0.987*
	PA3	-0.040	0.071	0.029	-0.053	0.024	0.813*

NOTE:

Factor loadings in bold indicate major loadings

Major loadings were freely estimated using uninformative priors(i.e. the default priors in Mplus)

Asterisks indicate 95% credibility interval does not contain zero

Table 4 shows the structural equations linking the latent variables of goal-frames and technophilia to individual and commute characteristics. Furthermore, it shows the structural equations according to the behavioral model.

TABLE 4 Estimates of the Structural Equations

<i>Part(1): Linking the goal-frames and technophilia to individual and commute characteristics</i>				
	Estimate	Posterior S.D.	95% PPI	90% PPI
Gain motives (F1)				
Male	-0.168	0.098	(-0.364) - (0.023)	(-0.330) - (-0.006)
Car use frequency	0.072	0.033	(0.006) - (0.138)	-
Transit use frequency	0.059	0.034	(0.008) - (0.126)	-
Travel Info use frequency for car	0.147	0.044	(0.062) - (0.237)	-
Travel Info use frequency for transit	0.088	0.046	(0.001) - (0.179)	-
Hedonic motives (F2)				
Male	-0.259	0.101	(-0.464) - (-0.067)	-
Normative motives (F3)				
Active mode use frequency	0.107	0.038	(0.033) - (0.181)	-
Travel Info use frequency for active mode	0.409	0.096	(0.226) - (0.602)	-
Income: Low	0.284	0.168	(-0.044) - (0.616)	(0.007) - (0.056)
Income: Medium	0.234	0.131	(-0.023) - (0.493)	(0.017) - (0.449)
Technophilia (F4)				
Male	0.216	0.104	(0.017) - (0.428)	-
Travel Info use frequency for car	0.214	0.046	(0.128) - (0.309)	-
Travel Info use frequency for transit	0.100	0.044	(0.016) - (0.190)	-
<i>Part(2): Linking the goal-frames, technophilia, social trust, place attachment and adoption intention</i>				
	Estimate	Posterior S.D.	95% PPI	90% PPI
Gain motives (F1)				
Social Trust (F5)	0.361	0.176	(0.078) - (0.773)	-
Place attachment (F6)	0.188	0.075	(0.043) - (0.340)	-
Hedonic motives (F2)				
Social Trust (F5)	0.405	0.189	(0.095) - (0.837)	-
Place attachment (F6)	0.284	0.087	(0.121) - (0.462)	-
Normative motives (F3)				
Social Trust (F5)	0.523	0.224	(0.174) - (1.050)	-
Place attachment (F6)	0.309	0.095	(0.122) - (0.495)	-
Adoption intention				
Gain motives (F1)	0.383	0.096	(0.201) - (0.577)	-
Hedonic motives (F2)	-0.135	0.074	(-0.281) - (-0.008)	-
Normative motives (F3)	0.099	0.061	(-0.020) - (0.220)	(0.001) - (0.200)
Technophilia (F4)	0.251	0.098	(0.063) - (0.447)	-

NOTE:*PPI stands for posterior probability interval**PPI values in bold indicate the corresponding credibility interval does not contain zero**The relation between the goal-frames, technophilia and individual characteristics*

According to Table 4, part (1), the latent constructs are significantly related to demographics, travel and information use habits, indicating their influence on individual attitudes and values developed by using the new app.

The value of using the app for improving trip efficiency i.e. “Gain motives” are stronger for respondents who (i) are female, (ii) commute more frequently by car and public transport (iii) and consult more frequently with travel information sources when commuting by car and public

transport. The results indicate that there is a strong relation between gain motives and the functional aspects of the app.

The motives related to the game elements i.e. “Hedonic motives” are negatively linked to male indicating a gender difference in the perceived value of the app. A previous study shows that social motivations for using online communication tools are stronger for female (41). Possibly, because the game attributes of the app mostly trigger social interaction (i.e. receiving feedback, being rewarded and information sharing), they are perceived more important for females as a new communication channel.

“Normative motives” are stronger for respondents who (i) commute more frequently with active modes, (ii) consult more frequently with travel information sources for commuting by active modes and, (iii) belong to low and middle income groups rather than high income. People who use active modes are driven by normative goal framing and thus are more prone to use the app on the same basis.

Technophile attitude is stronger for frequent users of travel information sources. Prior studies showed that the availability and use of information technologies (42), previous positive experience with travel information and favorable attitude towards their usefulness (43, 44) play an important role in individuals affinity to such technologies and use of ATIS.

The relation between the goal-frames, technophilia, social trust, place attachment and adoption intention

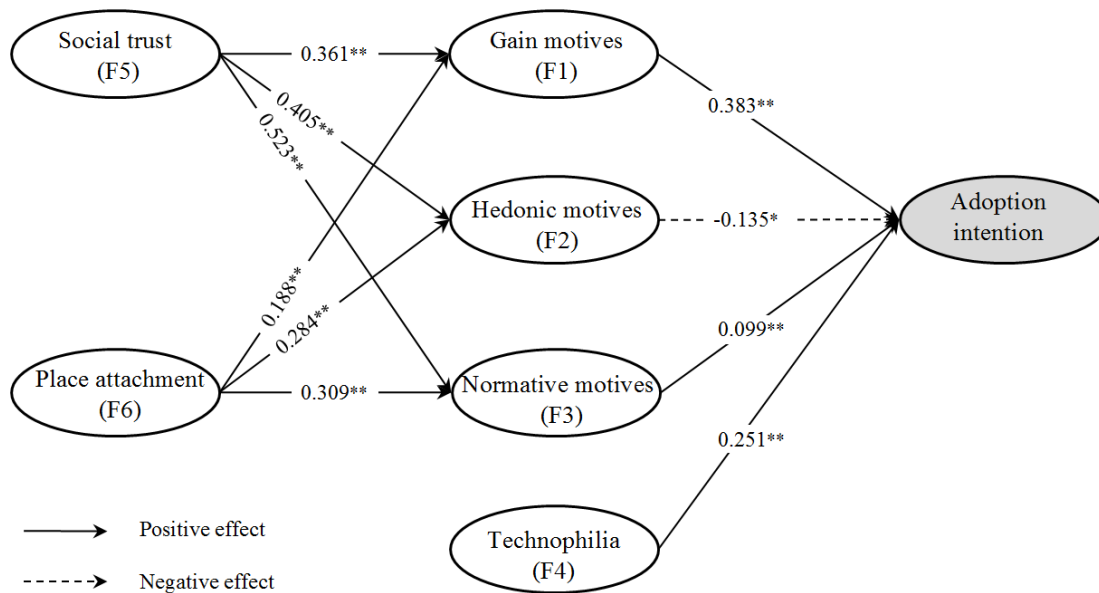
As shown in Table 4, part (2) and the path diagram of Figure 2, the model structure supported hypothesis H1 that the three distinct goal-frames relate to use intention. It suggests that acceptance and use of the VTBC-based travel app is associated not only with the functional value of the system but also with psychological needs such as social interaction, enjoyment, normative etc.

The specific results show that the “Gain motives” is positively related to adoption intention indicating functional usefulness as the fundamental value in adopting VTBC-based travel app. In line with goal-frame theory, the adoption intention is dominated by the gain goal of trip efficiency improvement since it has the highest positive coefficient. “Normative motives” and “Hedonic motives”, as the background goal frames, interfere with the gain goal and therefore affect adoption behavior. More specifically, the normative motives appear to promote the gain goal frame while the hedonic motives conflict with the dominant goal-frame. These results have important practical implications. Since gain motives play a significant role in adoption behavior, the usefulness of the system for time savings (i.e. travelling and information searching) and effort savings (i.e. searching information) should thus be stressed throughout the process of system development, business design and marketing. Furthermore, the value of green travel behavior which is triggered by persuasive strategies, are appealing to users of VTBC-based travel app and should therefore be emphasized in marketing materials.

Figure 2 also confirmed hypothesis H2 that adoption intention and users’ goal frames correlate positively with a stronger technophile attitude. It suggests those people with higher affinity to information technology are more likely to use the app, clearly characterizing technophiles as the key target group of this new generation of travel information systems. Understanding individual differences in terms of technological affinity/aversion could be helpful for the design and promotion of high-tech products such as ATIS by “informing the design of user interfaces and functionalities”, “enabling technophile early adopters for persuasive advertising”, and “improving customer segmentation” (45).

According to Figure 2, the model structure also confirmed hypotheses H3 i.e. indirect positive effect of place attachment and social trust constructs on the adoption intention. People with stronger social trust perceive the values of the new travel app as more relevant. For this group of people, in addition to trip efficiency improvement, the social, hedonic and normative motives are important drivers for their attraction and engagement. Collective efficacy as a social identity variable appears to develop a sense of collaborative engagement by the formations of goals intended to satisfy higher order needs such as sense of belonging, social approval and green travel promotion. Higher “Place attachment” relates positively to the three distinct goal-frames, suggesting that those individuals with stronger feelings of place attachment put more value and importance on the functional, social, hedonic and environmental attributes of the new travel app. For this group, their affective bonds with the city drive their opinion of the new information system and develop a positive evaluation of its value to improve the city's quality of life.

The social dynamic behind the system and its influence on users’ attitude and behavior indicate the importance of public engagement to achieve the goals of the system implementation. Urban areas are human environment systems in which participation is a key component to ensure sustainable urban planning. Public participation in sustainable mobility planning contributes to more efficient sustainable behavior promotion since it may facilitate changing people’s attitudes and behaviors and encouraging sustainable values. Furthermore, public acceptability of sustainable solutions such as ATIS could be triggered by public engagement (46). The public must be engaged at the start rather than towards the end of the planning process i.e. a shift from “design-defend-implement” to “discuss-design-implement”(47).



** = 95% Bayesian credible interval, * = 90% Bayesian credible interval

FIGURE 2 Model structure

CONCLUSION

The prevalence of smartphone use, the rise in mobile devices sensors and social media popularity for sharing information has influenced decision makers into thinking that collaborative travel app

could be a key to promote behavior change towards eco-friendly travel modes. However, the literature review revealed a lack of understanding about how individuals are motivated to accept and adopt VBTC-based travel app as well as the challenges related to users' attraction.

Our study examined to what extent gain, hedonic and normative motives together translate into the adoption behavior. The study provides empirical evidence that higher levels of gain and normative motives were both related to higher level of the app adoption while it is opposite for hedonic motives. Therefore, the potential users of the app could be categorized by being both functionally and normatively motivated not hedonically motivated. The strength of these effects indicates that gain motives dominate the adoption intention indicating the importance of the functional values of the system for users' attraction and engagement.

The results also show that technophiles are an important target group of VBTC-based travel app. They can play a significant role in promoting the use of this new generation of travel information system, thus contributing to a rapid increase in demand. However, the system attributes and functionalities should be designed aligned to the needs of both groups of technophiles and technophobes. On one hand, the entry threshold for unwilling users should be lowered (e.g. easy and understandable feature design) and on the other hand, tech-lovers should be appealed (e.g. providing the possibility of participatory design).

The results support that place attachment and social trust influence on users' attitude and behavior. It indicates that public engagement is important in ensuring the success of the system implementation. It is essential to develop a meaningful dialogue between decision makers and the public as to create its public acceptance. The public dialogue should be rest on – and accompanied by – a robust communication strategy to understand citizens travel needs and expectations, clarify the need for change in their travel behavior and underscore the importance of their contribution.

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AUTHOR CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: study conception, theoretical framework and survey design: A. Mehdizadeh D, S. Kaplan; data collection: A. Mehdizadeh D, J. Abreu e Silva; analysis and interpretation of results: A. Mehdizadeh D, S. Kaplan, J. Abreu e Silva, O.A. Nielsen, and F.C. Pereira; draft manuscript preparation: A. Mehdizadeh D, S. Kaplan, J. Abreu e Silva. All authors reviewed the results and approved the final version of the manuscript.

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